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(54) IMPROVEMENTS RELATING TO GAS LASERS

(71) We, FERRANTI LIMITED, a company registered under the Laws of Great Britain, of Hollinwood in the County of Lancaster, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to gas lasers, and particularly to such lasers of the high-power carbon-dioxide type.

Certain high power gas lasers use as the active medium a mixture of carbon dioxide, nitrogen, and helium. It has been found that the performance of such a laser falls off if the gas mixture is allowed to remain in the tube, and for this reason it is usual to replenish the gas mixture, continuously passing the mixture into the laser tube and venting it to the atmosphere. The disadvantage with this technique is that helium is an expensive material, and in the larger lasers a considerable quantity of helium is required.

It is believed that the fall-off in the performance of the laser is due, at least in part, to a change in the chemical composition of the gas mixture. The most probable reaction is represented by the following reversible equation, though other products containing one or more of the elements carbon, nitrogen or oxygen may be formed.

$$CO_2 + N_2 + He \rightleftharpoons CO + N_2O + He.$$

The carbon dioxide and nitrogen are changed, at least in part, by the effects of the electric discharge used to excite the laser, and form carbon monoxide and nitrous oxide. The helium is not affected chemically.

It is an object of the invention to provide a gas laser in which the rate of replenishment of the gas mixture is substantially reduced.

According to the present invention there is provided a gas laser comprising a discharge tube containing a gas mixture, which includes a closed-circuit gas circulation system comprising a pump for extracting the gas mixture from the laser discharge tube, a reaction vessel through which the gas mixture is passed by the pump, means for maintaining the reaction vessel at a temperature at which some or all of the dissociation of the gas mixture occurring in the laser discharge tube is reversed, and a throttle valve operable to control the pressure at which the gas mixture re-enters the laser discharge tube from the reaction vessel.

An embodiment of the invention will now be described with reference to the accompanying drawing. This shows, in schematic form, a laser tube and the associated gas circulation system.

Referring now to the drawing, the laser itself is shown in a simplified form as comprising a tube 10 having a pair of end mirrors 11 and 12, and being provided with two discharge electrodes 13 and 14. The remainder of the drawing shows the gas circulation system. Gas is extracted from the laser discharge tube by means of a pump 15, and is passed through an oil-mist filter 16A to remove any contamination due to the pump itself. After passing through the filter the gas mixture passes through an otherwise empty alumina tube 17 heated by a heating element 18, and thence through a silica-gel trap 16B to remove any water vapour or organic vapours. The gas mixture then returns through a throttle valve 19 to the laser discharge tube 10. The circuit between the throttle valve 19 and the pump 15 via the laser tube 10 is maintained at the low pressure required to operate the laser, whilst the remainder of the circuit is at a higher pressure, possibly above atmospheric pressure.

In order to allow for gas leakage from the system sources of the three gases are provided as shown at 20, 21, and 22, each being provided with a stop valve 23, 24 and 25 respectively. The gas mixture is bled into the high-pressure side of the circulation sys-

tem by means of a bleed valve 26. A pressure-relief valve 27 is also provided in the high-pressure side of the system, and communicates with the atmosphere. The rate of usage of the make-up gases from sources 20, 21 and 22 will be very small compared with the quantities required when the circulating gas mixture is exhausted direct to the atmosphere. It may be desirable to use flow-meters at various points in the circulation system, though these have not been shown in the drawing. The gases may, of course, be pre-mixed and drawn from a single cylinder.

In operation the heating element 18 is arranged to maintain the alumina tube 17 at a temperature of about 700°C. At this temperature the re-combination reaction occurs at the required rate. It may be necessary to cool the gases before passing them back into the laser discharge tube.

If the pump 15 is of a type which does not cause contamination of the gasses passing through it, then the oil-mist filter 16A may be omitted.

The heater 18 may be located either inside or outside the reaction vessel 17.

WHAT WE CLAIM IS:—

1. A gas laser comprising a discharge tube containing a gas mixture, which includes a closed-circuit gas circulation system comprising a pump for extracting the gas mixture from the laser discharge tube, a reaction vessel through which the gas mixture is passed by the pump, means for maintaining the reaction vessel at a temperature at which some or all of the dissociation of the gas mixture occurring in the laser discharge tube is reversed, and a throttle valve operable to control the pressure at which the gas mixture re-enters the laser discharge tube from the reaction vessel.

2. A gas laser as claimed in Claim 1 in which the reaction vessel is an alumina tube containing only the gas mixture.

3. A gas laser as claimed in either of Claims 1 or 2 in which the reaction vessel is maintained, in operation, at a temperature of the order of 700°C.

4. A gas laser as claimed in any one of the preceding claims in which the gas mixture in that part of the circulation system which includes the reaction vessel is maintained, in operation, at a pressure greater than that in the discharge tube.

5. A gas laser as claimed in any one of the preceding claims in which a silica gel trap is included in the gas circulation system between the reaction vessel and the throttle valve.

6. A gas laser as claimed in any one of Claims 1 to 5 which includes means for replacing one or more of the constituents of the gas mixture.

7. A gas laser substantially as herein described with reference to the accompanying drawing.

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